GRL PCIe Base Gen 3 MOI for Tektronix 8Gbps Physical Layer Test Suite

TABLE OF CONTENTS

1	INTRODUCTION	9
2	REFERENCE DOCUMENTS	9
3	RESOURCE REQUIREMENTS	10
	3.1 EQUIPMENT REQUIREMENTS	
	3.2 Software Requirements	
4	CALIBRATION	11
	 4.1 CALIBRATION PROCESS CONNECTION SETUPS 4.1.1 Calibration for TP1 4.1.2 Calibration for TP2 	
5	SOFTWARE	12
	5.1 SETUP5.1.1 Launch and Setup Software5.1.2 Additional Notes	
	 5.2 CALIBRATING USING THE SOFTWARE 5.2.1 Session Info	
	 5.2.4 Selecting Calibration Steps Using the Software 5.2.5 Run Calibration Steps 	
	 5.3 TESTING USING GRL-PCIE3-BASE-RX SOFTWARE 5.3.1 Receiver Compliance Tests 5.3.2 Receiver Margin Tests 	25 25 25
	5.4 Report	25
	 5.5 INTERPRETING A REPORT 5.5.1 DUT Information 5.5.2 Summary Table 5.5.3 Calibration Data Results 5.5.4 Compliance Test Results 5.5.5 Jitter Margin Results 	
6	TEST SUITE	30
7	APPENDIX A: ARTEK CLE1000-A2 INSTALLATION	30
	7.1 ISI GENERATOR DRIVER INSTALLATION	
	7.2 CLE1000 GUI INSTALLATION	
8	APPENDIX B: BERT SCOPE ISI TRACE BOARD	34

9 APPENDIX C: MANUAL TEST METHODS

9.1 V	/aveform Tests	35
9.1.1	Preshoot and Deemphasis	
9.1.2	Launch Amplitude	
9.1.3	Amplitude Equalization	
9.1.4	RJ Calibration	
9.1.5	SJ Calibration	
9.2 (HANNEL CALIBRATION TESTS (TP2)	
9.2.1	Channel Calibration Insertion Loss	
9.2.2	Channel Calibration Differential Mode Sinusoidal Interference	56
9.2.3	Channel Calibration AC Common Mode Sinusoidal Interference	58
9.3 (ALIBRATION AT TP2P	
9.3.1	TP2P Stressed Voltage Calibration	60
9.3.2	Stressed Jitter Calibration (For Long Channel Only)	
9.4 F	eceiver Test	
9.4.1	Equipment Setup	75
9.4.2	Stressed Voltage Receiver Test	
9.4.3	Stressed Jitter Receiver Test (100MHz)	79
10 PV	T AUTOMATION	82
10 PV 10.1	T AUTOMATION Available Parameters	82
10 PV 10.1 10.2	T AUTOMATION Available Parameters Applicable Tests	82
10 PV 10.1 10.2 10.3	T AUTOMATION Available Parameters Applicable Tests Setting up PVT Value Sequences	82
10 PV 10.1 10.2 10.3 10.4	T AUTOMATION Available Parameters Applicable Tests Setting up PVT Value Sequences Search Algorithm	82 82 82 83 83
10 PV 10.1 10.2 10.3 10.4 10.4	T AUTOMATION Available Parameters Applicable Tests Setting up PVT Value Sequences Search Algorithm Jitter Margin Testing	82
10 PV 10.1 10.2 10.3 10.4 10.4 10.5	T AUTOMATION Available Parameters Applicable Tests Setting up PVT Value Sequences Search Algorithm Jitter Margin Testing Test Results	82

List of Figures

Figure 1. Typical Setup for TP1 Calibration	
Figure 2. Typical Setup for TP2 Calibration	
Figure 3. Remote Client Window	
Figure 4. GRL Automated Test Solutions in Start Menu	
Figure 5. Rx Test Solutions in GRL Automated Test Solutions Window	
Figure 6. License Details Window	
Figure 7. OpenChoice Instrument Manager in Start Menu	
Figure 8. Instrument List in Instrument Manager	
Figure 9. Equipment Setup Window – View #1	
Figure 10. Equipment Setup Window – View #2	
Figure 11. Equipment Setup Window – View #3	
Figure 12. Session Info	
Figure 13. Conditions for Testing and Calibration	
Figure 14. ISI Generator Setup	
Figure 15. Custom SJ Frequencies	
Figure 16. Error Counter Setup	
Figure 17. Loopback Mode Setup	
Figure 18. BER and Maximum Errors	
Figure 19. Seasim Setup	
Figure 20. Connection Setup	
Figure 21. Select Calibration Tests Page	
Figure 22. Connection Setup	
Figure 23. Select Compliance Tests Page	
Figure 24. Select Margin Tests Page	
Figure 25. Report Results Page	
Figure 26. DUT Information	
Figure 27. Summary Table	
Figure 28. Calibration Results Example	
Figure 29. Calibration Results Example	
Figure 30. Jitter Margin Report Example	
Figure 31. Device Manager Window	
Figure 32. Update Driver Window	
Figure 33. Windows Security Window and Confirmation Window	
Figure 34. Device Manager Window after Installation	
Figure 35. CLE1000 GUI	
Figure 36. Insertion Loss per Trace Length	
Figure 37. Insertion Loss Connections Table	
GRL-PCIE3-RX MOI and User Guide	Rev. 1.2.0
@ Country Discout also 2016	$D_{2} = 1.4 \pm 0.07$

Figure 38. BERTScope Setup	
Figure 39. Scope Setup and Measurement	
Figure 40. Measured transition amplitude (Example 825mVpp)	
Figure 41. Measured non-transition amplitude (Example 254mV)	
Figure 42. Measured Preshoot amplitude (Example 622mV)	
Figure 43. BERTScope Setup #2	
Figure 44. Scope Setup and Measurement #2	
Figure 45. Amplitude Equalization Setup	
Figure 46. BERTScope Jitter Setup	
Figure 47. BERTScope Pattern Setup	
Figure 48. DPOJET Configure Setup	
Figure 49. RJDJ Setup	
Figure 50. Scope Advanced Setup	
Figure 51. Scope Record Length Setup	
Figure 52. Scope Waveform Capture	
Figure 53. BERTScope RJ Capture	
Figure 54. Sweep Jitter Range and Mask	
Figure 55. Sweep Jitter BERTScope Setup at 30KHz	
Figure 56. Sweep Jitter BERTScope Setup at 1MHz-100MHz	
Figure 57. Sweep Jitter DPOJET Measurement at 1MHz-100MHz	
Figure 58. Calibration at 1MHz-100MHz	
Figure 59. Sweep Jitter DPOJET Measurement at 1MHz-100MHz	
Figure 60. Channel Insertion Loss Mask by Channel Type	
Figure 61. ISI Setup	50
Figure 62 Scope Setup #1	50
Figure 63 Scope Setup #2	50
Figure 64 Scope Acquisition Mode Setup	
Figure 65 Capture Measurement	
Figure 66 Save the Waveform	
Figure 67 Seasim Insertion Loss Output Graph	53
Figure 68 Specification Mask	54
Figure 69 Insertion Loss at 27.5% ISI (-16.9dB)	
Figure 70 Insertion Loss at 30.% ISI (-17.9dB)	
Figure 71 Insertion Loss at 32.5% ISI (-18.9dB) Within Target	
Figure 72 Insertion Loss Calibration for Long Channel – IL falls between required mask	
Figure 73 BERTScope Setup for ALL ZERO Pattern	
Figure 74 BERTScope Setup #2	
Figure 75 Artek ISI Setup	
Figure 76 Scope Measurement	
CDL DCIE2 DV MOI and Hear Cuida	or 120

Figure 77 Scope Measurement	59
Figure 78 Setup for Calculating the Stressed Voltage Eye	60
Figure 79 Stressed Voltage Eye Parameters	60
Figure 80 Scope Setup	61
Figure 81 Acquired Waveform	62
Figure 82 Apply Seasim	62
Figure 83 Graphical Comparison of Original and After-Application Response	63
Figure 84 Graphical Step Response Comparison	63
Figure 85 Seasim Base Name Setup	64
Figure 86 Seasim Jitter/Noise Setup	65
Figure 87 Seasim Equalizer Setup	65
Figure 88 Seasim Simulated Eye Diagram #1	66
Figure 89 Seasim Simulated Eye Diagram #2	67
Figure 90 Seasim Simulated Eye Diagram #3	68
Figure 91 Layout for Long Channel Calibration	69
Figure 92 Specification for Long Channel Calibration	69
Figure 93 Scope Setup	70
Figure 94 Seasim Main Setup	71
Figure 95 Seasim Jitter/Noise Setup	72
Figure 96 Seasim Equalizer Setup	73
Figure 97 Waveform #1	74
Figure 98 Receiver Test Equipment Setup	75
Figure 99 Receiver Test Configure BERTScope	76
Figure 100 Receiver Test Configure for Stressed Jitter	77
Figure 101 Receiver Test Configure BERTScope Detector	78
Figure 102 Receiver Test Perform BER Test	78
Figure 103 Receiver Stressed Jitter Test BERTScope Setup	79
Figure 104 Receiver Stressed Jitter Test BERTScope Setup	
Figure 105 Receiver Stressed Jitter Test BERTScope Detector	
Figure 106 Receiver Stressed Jitter Perform BER Test	
Figure 107 Select PVT Configuration	
Figure 108 Add First PVT Automation Parameter	
Figure 109 Set each PVT Parameter Value in Sequence	
Figure 110 Add Second PVT Parameter	
Figure 111 Apply to Tests	
Figure 112 Select Applicable Tests	
Figure 113. Select PVT Tests to Run	
Figure 114 Run Tests with PVT	

List of Tables

Table 1. Equipment Requirements - Systems	10
Table 2. Equipment Requirements - Cables	10
Table 3. Presets for Waveform Tests	35
Table 4. Stressed Jitter Tests	45
Table 5. Available Parameters	82
Table 6. Applicable Tests	82
Table 7. PVT Automation – Internal Jitter Margin Search Algorithms	86
Table 8. PVT Automation – Iteration Sequence Example	87

Version	Revision Date	Description of Changes	Author(s)
1.0	5/2016	GRL-PCIE3-MOI Add Software Guide. Add Advanced Features.	Bill Altmann (GRL) baltmann@graniteriverlabs.com

Revision Record

1 Introduction

Receiver device compliance ensures correct data detection by the receiver for an acceptable bit error ratio (BER). PCIe Base Gen-3 devices shall support a BER that is less than 10⁻¹² (i.e., fewer than one bit error per 10¹² bits) when a signal with valid voltage and timing characteristics are delivered to the receiver compliance point [1]. The corresponding signal properties for verifying receiver tolerance should include the maximum allowable jitter, noise and signal loss.

This document describes the step by step calibration and procedures to perform the Receiver Jitter Tolerance test as specified in the PCIe Base 3.0 Standard using the Tektronix BERTScope. The BERTScope and appropriate accessories provide the necessary test patterns with jitter, ISI, and crosstalk. Additionally, the DPP125C Digital Pre-Emphasis Processor adds the required transmitter equalization. The receiver tolerance test includes various Differential Mode Sinusoidal Interference, minimum transmitter voltage amplitude, and jitter which includes random jitter including a sinusoidal periodic jitter component that is swept across specific frequency intervals.

Once the stressed receiver tolerance test setup has been calibrated the BERTScope transmits a Modified Compliance pattern to the receiver and monitors the loopback pattern has a BER that is less than 10^{-12} with a confidence level of 95%.

2 Reference Documents

[1] PCI Express® Base Specification Rev. 3.1a December 7, 2015

[2] Tektronix PCIe Gen3 Base MOI (55w-2428589-0)

3 Resource Requirements

3.1 Equipment Requirements

TABLE 1. EQUIPMENT REQUIREMENTS - SYSTEMS

Equipment	Qty	Description	Key Specification Requirement Tektronix P.N.
BSA125C or higher	1	12.5 Gb/s BERTScope	Requires option STR for stress generation
DPO/MSO70000DX	1	Real-time oscilloscope	≥ 20 GHz bandwidth
DPP125C or DPP125B	1	Digital Pre-Emphasis Processor	
CR125A or higher	1	12.5 Gb/s Clock Recovery Unit	Used for DUT-sourced reference clock applications. Not required for BERT- sourced reference.
Artek A2	1	ISI Generator	Programmable ISI Generator (optional)
AFG3000 1		Arbitrary Function Generator	120MHz Sine Wave Generator
Combiner	1	Combine Differential Mode (D Mode with stressed Rx test pa	OMI) and AC Common attern.
Seasim Application from PCI-SIG	1	Simulation Software of Eye Opening at TP2P	

 TABLE 2. EQUIPMENT REQUIREMENTS - CABLES

Equipment	Qty.	Key Specification Requirement Tektronix P.N.
T+M SF104PE/11PC35/11PC35/500mm	3	174-6663-00
T+M SF104PE/11PC35/11PC35/1000mm	2	PMCABLE1M
T+M MF141/16SMA/16SMA/200mm	3	174-6664-00
T+M MF141/16SMA/16SMA/300mm	1	174-6665-00
T+M MF141/16SMA/16SMA/500mm	1	174-6666-00
T+M MF141/11SMA/16SMA/1.829M	2	174-6667-00

3.2 Software Requirements

See Table 1.

4 Calibration

PCIe calibration will be done at 3 test points: TP1 and TP2 and TP2P. TP1 is a physical test point for calibration without the effect of breakout channel length. TP2, is test point that will affect the eye opening due to trace length. TP2P, is an test point calculated by software tool *Seasim* to simulate the eye opening after applying Rx Behavioral package, Rx CTLE, DFE (if required).

4.1 Calibration Process Connection Setups

4.1.1 Calibration for TP1



FIGURE 1. TYPICAL SETUP FOR TP1 CALIBRATION

Connection Steps:

- 1. Connect BERTScope Data(+) to DPP.
- 2. Connect BERTScope Clk Out to DPP.
- 3. Connect DPP Data(+) out to Combiner In.
- 4. Connect DPP Data(-) out to Combiner In.
- 5. Connect AFG Output1 to Combiner CM-IN.
- 6. Connect BERTScope (real panel) SI-out to Combiner DM In.
- 7. Connect Combiner Data Out to Tek Scope Chan1 and Chan2.

4.1.2 Calibration for TP2



FIGURE 2. TYPICAL SETUP FOR TP2 CALIBRATION

Connection Steps:

- 1. Connect BERTScope Data(+) to DPP
- 2. Connect BERTScope Clk Out to DPP
- 3. Connect DPP Data(+) out to Combiner In
- 4. Connect DPP Data(-) out to Combiner In
- 5. Connect AFG Output1 to Combiner CM-IN
- 6. Connect BERTScope (real panel) SI-out to Combiner DM In
- 7. Connect Combiner Data Out to Artek ISI Box Input
- 8. Outputs of Artek ISI Box connect Tek Scope Chan1 and Chan2

5 Software

5.1 Setup

This section provides procedures for installing, configuring, and verifying the operation of the GRL PCIe Base 3.0 Rx Test solution. It also will help you familiarize yourself with the basic operation of the application.

The software installer automatically creates short cuts in the Desktop and Start Menu.

To open the application, follow the procedure in the following section.

5.1.1 Launch and Setup Software

5.1.1.1 On the BERTScope

- 1. Select View > System > Tools Tab.
- 2. Under Utilities Column, press the Remote button.
- 3. In Remote Window, Select TCP/IP.
- 4. Change Terminator to "LF". Press the Connect Button. See Figure 3.
 - a) If you see an error pop-up when pressing the Connect button. Try a different Port. For example, change Port 23 to 21.
- 5. Address and Port # on Remote Client. It will be needed to connect BERTScope to automation software.
- 6. Minimize, but do not close, the *Remote Client* Window.

Remote Client Version: 10.15 Build: 1314.	_ 🗆 X
Trace Messages	
🔽 Scroll Dutput	
Timestamp	
F GUI Lockout	
Identity: BSA125C	
Terminator: LF 🗸	
C IEEE488 C TCP/IP	
TCP/IP Settings	
IP Addr: 192.168.0.39	
Port: 23 default	
Connected Disconnect	
Save Log to File Clear	

FIGURE 3. REMOTE CLIENT WINDOW

5.1.1.2 On the PC Used for GRL Framework Installation.

1. Navigate to Start Menu > All Programs > GRL > GRL Automated Test Solutions.



FIGURE 4. GRL AUTOMATED TEST SOLUTIONS IN START MENU

2. Click Application>Rx Test Solution>PCIe 3.0 Base Rx Test to open the application.



FIGURE 5. RX TEST SOLUTIONS IN GRL AUTOMATED TEST SOLUTIONS WINDOW

3. To enable license, go to License->License Details. The dialog in Figure 6 will pop up.

Frame	ework License Detail	S	
nstalled Products:			
Licensed To: GRL Lenovo			-
SAS Sink Test - DEMO			
Host ID (For enquiries or license r QqEx06bSTAHmjluun8NJp3q0a Qpw90qE8XjWCyTUD21x7dtQ3	request please send this in W5mh5YMEp+yAAd4EKc 3T9fn440HFSYwLoSX/pb	formation): Sn7IAB3g 🔺 DuedMc6	Copy to
+NKu5M0MuYkfdpEdguvGII7Uz For license enquiries send the He	tjwKKRVSc1gO+RWBalL ost ID to <u>support@Gran</u>	QZUXhy -	Clipboard
Activation Key Received:			
		-	
a company of the second s			Activato

FIGURE 6. LICENSE DETAILS WINDOW

- 4. Activate License:
 - a) If you have an Activation Key, please enter in the box provided and press Activate.
 - b) If you do not have an Activation Key, press **Close** to use the SW for 10 Days free of charge.

Note: Once the 10-day trial times out, you will need to request an activation key for future usage on the same computer or oscilloscope. The demo SW is also limited in its capability in that it will only calibrate the maximum frequency for each data rate. Thus, the demo version cannot be used to fully calibrate and test a device. For Demo and Beta Customer License Keys, please request a License key by contacting <u>support@graniteriverlabs.com</u>.

- 5. Click on Equipment Setup icon ion the GRL Framework.
- 6. Enter the BERTScope IP address and Port number to match what is in the BERTScope *Remote Client* window shown in Step 4-5.
- 7. Attach Tek AFG via USB to TekScope / Connect with LAN.

File	Edit	Vertical	Digital	Horiz/Acq	Trig	Display	Cursors	Measure	Mask	Math	MyScope	Analyze	Utilities	Help	-		MSC	7330-	IDX ¹	Tek		X
		' '				· · !								' !		1	<u>'</u>			<u>'</u>	1 1	
E											-											
E																						
E											+ - 											
E											-											
	GRI	L - Autom	ated Test	Solutions	_						+ + +											
	Not	tepad			•	Tek Loc	al Admin				- 											
Tek	Tek	Scope				Docume	ante				-											
	Wir	ndows Exp	olorer		•	Dictures		Ψ'n	un alabat	ester freihender freihen son die state di State die state die st	wayll angell game	manhantp	dan di kaliya in	when	*****	With the	-l _{ol} lin	where where	ry-wy	- MAR	hoj-hap-re	nindadi 🕌
6	Inte	ernet Expl	orer		•	Music					* - -											
h	Lau	inch Disp	ayPort Al	JX Control				- 1			• · · ·											
	- Tea	mViewer	10			Games					+											
	USE	3 3.0 Rece	iver Testir	ng		Comput	er	- 1			-											
	Dai	nt				Control	Panel				- - - · · ·											
2						Devices	and Printe	rs			+ + -											
VIS		1000				Default I	Programs															
8	o Op	enChoice	Instrume	nt Manager		Help and	d Support				- -											1
	All I	Programs						<u>i</u>	1 1	1 1					1							
S	earch	programs	and files	ļ	0	Shut dov	vn 🕨					A' 🦲	1 7 0.0	V			2.0ns/ Run	aiv	Sar	nple	20.0p	s/pt
	2	C:N_		Tek													0.4.0	400 L.		⊳	8:2!	5 PM

8. On Tek Scope, open the application **OpenChoice Instrument Manager**. See Figure 7.

FIGURE 7. OPENCHOICE INSTRUMENT MANAGER IN START MENU

- 9. Instrument Manager will display all the connected instruments on its list, as in Figure 8:
 - a) GPIB8::1::INST (Tek Scope)
 - b) TCPIP::192.168.0.39::23::SOCKET (BertScope)
 - c) USB:: 0x0699::0x0345::C022203::INSTR (AFG)

File	Edit	Vertical	Digital	Horiz/Acq	Trig	Display	Cursors	Measure	Mask	Math	MyScope	Analyze	Utilities	Help 🔽	MSC	73304DX	Tek		X
E		' ' <u>!</u>													'''			1 1 1	
										-									
E					nenChoir	ce Instrur	ment Man	ager											
F				File	Edit He	elp													
E					Instrume	ents						Applicatio	ons and	Utilities					
F					GPIB GF	PIB8::1::	INSTR	0	OVET			Ope	nChoice	Call Monitor					
E					USB US	B::0x06	99::0x03	45::C0222	03::INS	TR		ope	nonoice	runter Elote					
E																			
	the Real P	با مىسىل		LANAL C														alas a Mada	
T		ala mene	ana mala ang													4-4an uiles		1997 - 1997 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 - 1994 -	
E					•					F									
					Last Upd	lated: 5/	10/2015	8:25 PM											
E					Instru U	iment Li pdate	ist	Instru Identi	ment fy										
												Star	t Applica	tion or Utility					
E					Searc	h Criteri	a	Prope	rties.					-					
						<u> </u>								Tekt	ronix				
														· · · ·					
E	1 1	<u> i</u>		<u> i</u>				ı i				i			<u> i</u>		- i		
	C1	100mV/di	iv	50Ω Bγ	:23.0G							A'	10.0	v	2.0ns/	div 50.0G	S/s	20.0ps/	pt
				Tek											Ruh	52 770	ampie	0.25-0	
	3	C:N_	- (3)		j 🛛 😌		7									<u> </u>	P 12	8:25 P 5/10/20	015

FIGURE 8. INSTRUMENT LIST IN INSTRUMENT MANAGER

10. Note these settings, as in Figure 9 and Figure 10:

- a) Enter the Scope IP Address.
- b) Enter BertScope IP Address.
- c) Enter Tektronix AFG USB/IP Address.
- d) Enter the COM Address of the ISI Generator to be used.

Applicat	.0 Base Rx Test ion Options S	Setup License	Windows Help							a x
Equipn	nent Setup			i 🔅 🔶 🙆	🔅 🥅 🗕 🍉	→ 📄 🔪			(2	
	Name	ID	Address	Туре	Vendor	Lib				0
	Scope	Scope	GPIB8::1::INSTR	Oscilloscope	Tektronix 🔻	TekDPOJETSc 👻	6			
	BERT	BERT	127.0.0.1:23	BERT	Tektronix 👻	TekBertScope -	1		E	
	ISI Generator	ISIGen	COM13	ISI Generator	Artek -	StandardSerial -	1			
	AFG	AEC	102 169 0 46	Other				•	•	

FIGURE 9. EQUIPMENT SETUP WINDOW – VIEW #1

Application Options Setup License Windows Help		
Equipment Setup	[] ◎ 🔶 ◎ 📾 → 🕨 → 🧮	2
Scope Scope GPIB8::1::INSTR	Oscilloscope Tektronix TekDPOJETSc	8
BERT BERT 127.0.0.1:23	BERT Tektronix • TekBertScope • 🎸 📮	
ISI Generator ISIGen COM13	ISI Generator Artek StandardSerial	
AFG AFG 192.168.0.46	Other Tektronix GenericVISA	
	m. F	

FIGURE 10. EQUIPMENT SETUP WINDOW – VIEW #2

- 11. Check the connection by pressing the "lightning" button \checkmark . The "lightning" button should turn green if the connection has been verified.
- 12. Do this for each instrument that that will be used, as shown in Figure 11.

pn	nent Setup			3 🔶 🕲) 🔲 🕂 📂	+	_	0	2
ſ	Name	ID	Address	Туре	Vendor	Lib	-		
	Scope	Scope	GPIB8:1::INSTR	Oscilloscope	Tektronix 🔹	TekDPOJETSc •	4		
	BERT	BERT	192.168.0.39:23	BERT	Tektronix -	TekBertScope +	Ø		
ľ	ISI Generator	ISIGen	COM3	ISI Generator	Artek +	StandardSerial +	4		
	AFG	150	100-0-0000-0-0-01	Other	Teletation	[]			

FIGURE 11. EQUIPMENT SETUP WINDOW – VIEW #3

5.1.2 Additional Notes

The USB driver SW for the ISI Generator being used must be installed on the PC being used for testing and the ISI Generator must be connected to the PC via USB. The driver for the ISI Generator is available from the ISI Generator manufacturer. Refer to Appendix of this document for driver installation information for supported ISI generators.

5.2 Calibrating Using the Software

5.2.1 Session Info

The information provided will be included in the report.

The DUT Information and Test Info are input by the user.

The SW Versions information is automatically populated.

6	Rx Test Solution	- P ×
Application Options View Pre	ference License Help	
Session Into		
	DUT Info Test Info Software Info DUT Manufacturer: ACME TECHNOLOGIES DUT Model Number: DP1 DUT Serial Number: 1000	

FIGURE 12. SESSION INFO

5.2.2 Conditions for Testing and Calibration

In this section, conditions for Testing and Calibration will need to be set. User selects conditions for testing and for calibration.

When calibrating, the application will calibrate the selected range, Sj frequency, common mode voltage and differential voltage that the user chooses.

Recommended procedure:

- 1. When calibrating, select conditions for calibration and perform desired calibration
- 2. When testing: re-select desired conditions for testing. For example, it may be only necessary to test range A at Sj frequency. The user would select the appropriate conditions for test



FIGURE 13. CONDITIONS FOR TESTING AND CALIBRATION

5.2.3 Setup Configuration

5.2.3.1 ISI Generator Setup

If test is running using BERTScope ISI Trace board (For more information on how to generate desired insertion loss using BERTScope ISI Trace board, please refer to Appendix B), user can set the ISI to NONE.



FIGURE 14. ISI GENERATOR SETUP

5.2.3.2 Custom SJ Frequency

Set Custom SJ frequency to test for condition setup on previous tab.

Application Options Setup License Windows Help
Setup Configuration 2 $ ($
ISI Generator Custom SJ Frequencies Error Counter Loopback Mode Compliance Margin Search Params Seasim Settings 1 Custom SJ1: 0.100 MHz Custom SJ2: 2.000 MHz Custom SJ3: 10.000 MHz

FIGURE 15. CUSTOM SJ FREQUENCIES

5.2.3.3 Error Counter

Select Receiver base DUT loop back capability. If DUT can be configured to loop back mode, select Loopback, else select Manual.

	Connection Margin Search Params Preset Setting	G
4	Ener Count Method: Manual o	
		4

FIGURE 16. ERROR COUNTER SETUP

Details on the use of Manual mode will be provided in a future version of this document.

5.2.3.4 Loopback Mode

If the user selected loopback on the Error Counter tab, then the user needs to select "Clock Recovery" in the Clock Recovery Method drop-down on the Loopback Mode tab. *Other options on the Clock Recovery Method drop-down are not yet supported.*

Setup Configuration	<i>t</i> ① ◆ ◎ ■ ★ + ▶ → ■	0 🖌
•	Connection Margin Search Parama Presid Setting ISI Generator Random Jitter Setting Custom SJ Frequencies Error Counter Loopback Mode Compliance Season Settings Clock Recovery Loop Bandmidth: Le6 Custom Pattern for Enror Detector ED Pattern: ALLZERO	

FIGURE 17. LOOPBACK MODE SETUP

PCIE uses the default pattern.

Details on the use of Custom Patterns will be provided in a future version of this document.

5.2.3.5 Compliance Tab

Set BER and Maximum Error allowed for testing. These limits are set by the Specification. Other limits may be set in these fields by the user. The syntax '1e-12' indicates 10⁻¹², and is the only syntax supported in this field.

Setup Co	onfiguration		1 8 6) 🔶 🚺	🛯 + ≽ + 🗎	V		0	
	Custom SJ Frequencies	Error Counter	Loopback Mode	Compliance	Margin Search Params	Seasim Settings	Connection * *		C
	Compliance BER	1e-12	2						-
	Maximum Error.	0							
									1

FIGURE 18. BER AND MAXIMUM ERRORS

5.2.3.6 Seasim Tab

Set if user wishes to use the Rx Behavioral package during Eye Height and Eye Width Calibration. Also set the intrinsic jitter (if required) to be used in the Seasim calculation.

plication tup Cor	Options Setup License	Windows	Help	। 🄶 🏟	₩ → ► → 🛅	(0
	Custom SJ Frequencies	Error Counter	Loopback Mode	Compliance	Margin Search Params	Seasim Settings	Connection 4	
	User Rx Package:		True	•	-			
	Intrinsic No	ise:	0.0					

FIGURE 19. SEASIM SETUP

Details on the use of 'False' in the User Rx Package field will be provided in a future version of this document

5.2.3.7 Connection Tab

Setup connection of Data+ and Data- in Scope. Scope channels shall be assigned according to how the scope cables are attached to the test setup.

se Rx Test	Wednus Hele					- 6	×
figuration	e windows hep	! 💿 🔶 💿	📷 + ⊳ + 🗎	6		0	
Custom SJ Frequencies	Error Counter Loopback	Mode Compliance	Margin Search Params	Seasim Settings	Connection 💌		0
Data	+ Chan1						
Data	- Chan2	•					
	se Rx Test Options Setup License figuration Custom SJ Frequencies Data Data	e Rx Test Options Setup License Windows Help figuration Custom SJ Frequencies Error Counter Loopback Data + Chan1 Data - Chan2	e Rx Test Options Setup License Windows Help figuration Custom SJ Frequencies Error Counter Loopback Mode Compliance Data + Chan1 • Data - Chan2 •	se Rx Test Options Setup License Windows Help figuration Custom SJ Frequencies Error Counter Loopback Mode Compliance Margin Search Params Data + Chan1 - Data - Chan2 -	se Rx Test Options Setup License Windows Help figuration Custom SJ Frequencies Error Counter Loopback Mode Compliance Margin Search Params Seasim Settings Data + Chan1 Data - Chan2	ere Rx Test Options Setup License Windows Help figuration Custom SJ Frequencies Error Counter Loopback Mode Compliance Margin Search Params Seasim Settings Connection Data + Chan1 Data - Chan2	ere Rx Test Options Setup figuration Custom SJ Frequencies Error Counter Loopback Mode Compliance Margin Search Params Seasim Settings Connection Image: Street of the seasing of the seasing search parameter of the seasing seasing search parameter of the seasing seasing search parameter of the seasing seasi

FIGURE 20. CONNECTION SETUP

5.2.4 Selecting Calibration Steps Using the Software

The **Select Calibration Tests** page is the place where the calibration tests that need to be performed are selected. Initially, when starting for the first time or changing anything in the setup, it is suggested to run Calibration first. If the calibration is not completed, the RX Tests will show an error message.



FIGURE 21. SELECT CALIBRATION TESTS PAGE

5.2.5 Run Calibration Steps

From the pop-up menu, select the Run icon: 🔳

Skip Test if Results Exist. If previous calibration results exist, then software will *skip* calibration steps that have existing reports.

Replace if Results Exist. If previous calibration results exist, then software will replace each step in calibration with new results.

(Restart) Delete Existing Results. All previous results will be deleted, and each selected step in calibration will generate new report.



FIGURE 22. CONNECTION SETUP

5.3 Testing using GRL-PCIE3-BASE-RX Software

5.3.1 Receiver Compliance Tests

The **Select Tests** page is the place where the compliance tests that need to be performed are selected.



FIGURE 23. SELECT COMPLIANCE TESTS PAGE

Tests are run from the same screen as shown in Section 5.2.5.

5.3.2 Receiver Margin Tests

The **Select Tests** page is the place where the compliance tests that need to be performed are selected.



FIGURE 24. SELECT MARGIN TESTS PAGE

Tests are run from the same screen as shown in Section 5.2.5.

5.4 Report

The **Report** page has all the results from all the test runs displayed. If some of the results are not desired, they can be individually deleted by using the Delete button. Also for a pdf report, click the Generate Report button. To have the calibration data plotted in the report, make sure the Plot Calibration Data box is checked.



FIGURE 25. REPORT RESULTS PAGE

5.5 Interpreting a Report

5.5.1 DUT Information

This portion is populated from the information in the DUT tab from the **Session Info** tab.

DUT Information		
DUT Manufacturer	:	
DUT Model Number		
DUT Serial Number	÷1	
Test Information		
Test Lab	3	
Test Operator	:	
Test Date		
Software Version		
Software Revision	: 0.0.0.1	
Tek BERTScope FW	: 10.15	
DPOJET Version	: 6.2.0.68	
Tek Scope FW	: 7.1.3	

FIGURE 26. DUT INFORMATION

5.5.2 Summary Table

This portion is populated from the tests performed and its results. This gives an overall view of all the results and its test conditions.

No	TestName	Limits	Value	Results	De- Emphasis	Voltge Swing	SJ
1	Pre-shoot Calibration	True/False	True	Pass	1		
2	De-emphasis Calibration	True/False	True	Pass			1
3	Launch Amplitude Calibration	True/False	True	Pass			
4	Rj Calibration	True/False	True	Pass			1.5.5
5	Sj Calibration	True/False	True	Pass	N/A	N/A	SJLF 1
6	Sj Calibration	True/False	True	Pass	N/A	N/A	SJLF 2
7	Sj Calibration	True/False	True	Pass	N/A	N/A	SJLF 3
8	Sj Calibration	True/False	True	Pass	N/A	N/A	SJLF 4
9	CM Sinusoidal Interference Calibration (Short)	True/False	True	Pass			10.5
10	DM Sinusoidal Interference Calibration (Short)	True/False	True	Pass			
11	Stressed Voltage Calibration (Short)	True/False	False	Fail			
12	CM Sinusoidal Interference Calibration (Long)	True/False	True	Pass			
13	DM Sinusoidal Interference Calibration (Long)	True/False	True	Pass			
14	Stressed Voltage Calibration (Long)	True/False	False	Fail			1.1
15	Stress Jitter Calibration (Long)	True/False	False	Fail		10.0	57.0
16	Insertion Loss Calibration (Long)	True/False	True	Pass		(2)	21
17	Insertion Loss Calibration (Short)	True/False	True	Pass			
18	Insertion Loss Calibration	True/False	False	Fail		-	

FIGURE 27. SUMMARY TABLE

5.5.3 Calibration Data Results

If Plot Calibration Data checkbox is checked, then the plots are shown in this part of the report.



FIGURE 28. CALIBRATION RESULTS EXAMPLE

5.5.4 Compliance Test Results

No	TestName	Limits	Value	Results	SJ
1	PG Delay Calibration	True/False	True	Pass	
2	Sj Calibration	True/False	True	Pass	User_SJ1
3	Sj Calibration	True/False	True	Pass	User_SJ2
4	Sj Calibration	True/False	True	Pass	User_SJ3
5	Stress Jitter Sweep Test (Long)	True/False	False	Fail	
6	Stress Jitter Test (Long)	True/False	False	Fail	SJLF_2
7	Stress Jitter Test (Long)	True/False	True	Pass	SJLF_4
8	Stress Jitter Test (Long)	True/False	True	Pass	User_SJ1
9	Stress Jitter Test (Long)	True/False	True	Pass	User_SJ3
10	Insertion Loss Calibration (Long)	True/False	True	Pass	1 1 2 1 1 1
11	CM Sinusoidal Interference Calibration (Long)	True/False	True	Pass	
12	DM Sinusoidal Interference Calibration (Long)	True/False	True	Pass	
13	Stressed Voltage Calibration (Long)	True/False	True	Pass	
14	Stress Jitter Calibration (Long)	True/False	True	Pass	The second
15	Sj Calibration	True/False	True	Pass	User SJ4
16	Sj Calibration	True/False	True	Pass	User SJ5
17	Stress Voltage Test (Long)	True/False	True	Pass	
18	Stress Jitter Test (Long)	True/False	False	Fail	SJLF 3
19	Stress Jitter Test (Long)	True/False	True	Pass	User SJ2
20	Stress Jitter Sweep Test (Long)	True/False	True	Pass	SJLF 3
21	Stress Jitter Sweep Test (Long)	True/False	True	Pass	SJLF 2
22	Stress Jitter Sweep Test (Long)	True/False	True	Pass	User SJ2
23	Stress Jitter Margin Test (long)	True/False	True	Pass	User SJ3
24	Stress Voltage Margin Test (long)	True/False	False	Fail	
25	Stress Jitter Margin Test (long)	True/False	True	Pass	User SJ2
26	Pre-shoot Calibration	True/False	True	Pass	B. B. Charles
27	De-emphasis Calibration	True/False	True	Pass	1 Ja 21
28	Launch Amplitude Calibration	True/False	True	Pass	- B
29	Rj Calibration	True/False	True	Pass	
30	Sj Calibration	True/False	True	Pass	SJLF 1
31	Sj Calibration	True/False	True	Pass	SJLF 2
32	Sj Calibration	True/False	True	Pass	SJLF 3
33	Sj Calibration	True/False	True	Pass	SJLF 4
34	Insertion Loss Calibration	True/False	True	Pass	

PCIe 3.0 Base Rx Test Report

FIGURE 29. CALIBRATION RESULTS EXAMPLE

Jitter Margin Test(Result Main) 150 Tolerance Compliance Limits Pass Fail 122.5 95 SJ(ps| 67.5 40 12.5 -10000 1000000 100000000 100000 10000000 1000000000 SJ Frequency (Hz)

FIGURE **30.** JITTER MARGIN REPORT EXAMPLE

6 Test Suite

The PCIE3 Base Specification tests are listed in the drop-down menus in the equipment described in this MOI.

7 Appendix A: ARTEK CLE1000-A2 Installation

7.1 ISI Generator Driver Installation

If using ARTEK CLE1000-A2 for Variable ISI Calibration, follow these steps to install the ISI generator driver before selecting it as an ISI channel in the *DP Configuration Utility*.

- 1. Connect the CLE1000-A2 to the PC being used as the controller, using a USB 2.0 cable.
- 2. Turn on the front panel power switch on the CLE1000-A2.
- 3. Right Click on My Computer > Manage > Device Manager. If no SW for the CLE1000-A2 has been installed, you will see a 'bang' in the device manager. See Figure 31.

Computer Management (Local) System Tools Charles And Charles An	Actions Device Manager
I Services and Applications Imaging devices Imaging devices Imaging devices </td <td>More Actions</td>	More Actions

FIGURE 31. DEVICE MANAGER WINDOW

- 4. To install the CLE1000-A2, go to http://www.aceunitech.com/support.html and download the Control SW package for the CLE1000.
- 5. Unpack the CLE1000 SW .zip file.
- 6. Install the CLE1000 Driver:
 - a) In Device Manager, right click on **CLE1000** > **Update Driver**.
 - b) Select Browse My Computer for Driver from Windows dialog. See Figure 32.
 - c) Browse to the root directory of the unzipped CLE1000 SW folder.
 - d) Press Next. You will be asked to confirm your request to install a driver.
 - e) Press Install. Driver SW will complete installation.
- 7. Once Installation completes, the Device Manager should look like Figure 34.

Bro	wse for driver software on your computer
earc	h for driver software in this location:
C:\l	Jsers\goliad 12 MLK\Desktop\CLE
<u>Z</u> In	clude subfolders
•	Let me pick from a list of device drivers on my computer This list will show installed driver software compatible with the device, and all driver software in the same category as the device.

FIGURE 32. UPDATE DRIVER WINDOW



FIGURE 33. WINDOWS SECURITY WINDOW AND CONFIRMATION WINDOW



FIGURE 34. DEVICE MANAGER WINDOW AFTER INSTALLATION

The CLE10000 SW driver is now installed and the CLE1000 can now be selected for use remotely using the GRL *DP Configuration Utility*.

7.2 CLE1000 GUI Installation

It may also be useful to install the CLE1000 GUI, so that the ISI channel can also be controlled manually from the PC. To install the SW, do the following:

- 1. In the CLE1000 SW folder, click on the Setup.exe file. Once installed successfully, the following GUI will appear on the desktop.
- 2. You can now close the GUI if you don't want to have manual control.

ISI MAGNITUDE		58.0	%
0%	50%		100%
	<u> </u>	1 1 1	

FIGURE 35. CLE1000 GUI

8 Appendix B: BERT Scope ISI Trace Board

The BERTScope ISI Trace Board is required for PCIe Base 3.0 Insertion Loss tests.

Figure 36 describes the insertion loss at 4GHz on various trace lengths on the BERTScope ISI Trace Board.

1	2.42 inch	5 inch	6.75 inch	9 inch	12 inch	17 inch	24 inch	31 inch	40 inch
FREQ MHz	Sdd21 dB	Sdd21 dB	Sdd21 dB	Sdd21 dB	Sdd21 dB	Sdd21 dB	Sdd21 dB	Sdd21 dB	Sdd21 dB
4000	-0.89	-1.73	-2.34	-2.99	-3.9	-5.49	-7.63	-9.7	-12.54

FIGURE 36. INSERTION LOSS PER TRACE LENGTH

For PCIe Gen3. 3 Type of trace length to be tested, follow the table in Figure 37 to connect points of trace board to get the desired insertion loss.

	Target Insertion Loss(I.L.)	Trace Length(Insertion Loss)
		6.75 inch (-2.34dB)
Replica Channel	-2.5 +/- 1dB	Total I.L. = -2.34dB
Replica Channel +	12.0 -/ 210	6.75 inch (-2.34dB) 31 inch (-9.7 dB)
Short Channel	-12.0 + /- 2dB	Total I.L. = -12.04 dB
		6.75 inch (-2.34dB) 17 inch (-5.49 dB)
teplica Channel + Long Channel	-20 +/- 2dB	40 inch (-12.54 dB)
		Total I.L. = -20.46 dB

FIGURE 37. INSERTION LOSS CONNECTIONS TABLE

9 Appendix C: Manual Test Methods

9.1 Waveform Tests

9.1.1 Preshoot and Deemphasis

PCIe Base uses two presets for different trace lengths of the breakout board. Both Deemphasis and Preshoot are calibrated for the target dB for each preset. See Table 3.

TABLE 3. PRESETS FOR WAVEFORM TESTS

Preset	Preshoot	Deemphasis
4	0.0dB	3.5dB
7	0.0dB	-6.0dB

9.1.1.1 BERTScope Setup

- 1. Set the BERTScope to defaults.
- 2. Set Generator to 8Gpbs (PCIe Gen3 Speed)
- 3. Disable All stressed jitter component (Rj, Sj etc)
- 4. Set the Output amplitude to 800mV
- 5. Set the DPP Output 460mV
- 6. Default the DPP to 0.0dB Preshoot and Deemphasis, as shown in Figure 38.
- 7. Load with 64 ONEs , 64 ZEROs and 128 Clk Pattern to BERTScope.



FIGURE 38. BERTSCOPE SETUP

9.1.1.2 Scope Setup & Measurement

- 1. Set the scope to Defaults.
- 2. Set scope Sampling mode to Real Time Only.
- 3. Set scope acquisition to average with 256 waveforms.
- 4. Set the trigger of A_Event type to timeout.
- 5. Set Chan1 and Chan2 display to ON; configure the scale and offset so the waveform covers 80% of the screen.
- 6. Enable Math1; set Math1 to Ch1-Ch2; set the auto scale.
- 7. Turn off Chan1 and Chan2.
- 8. Acquire Waveform. An example is shown in Figure 39.



FIGURE 39. SCOPE SETUP AND MEASUREMENT
9.1.1.3 Deemphasis Measurement

Now, the actual de-emphasis and pre-shoot must be verified on scope.

1. Using cursors, measure peak-to-peak transition amplitude as shown Figure 40.



FIGURE 40. MEASURED TRANSITION AMPLITUDE (EXAMPLE 825MVPP)

2. Using cursors, measure peak-to-peak non-transition amplitude, as shown in Figure 41.



FIGURE 41. MEASURED NON-TRANSITION AMPLITUDE (EXAMPLE 254MV)

- 3. De-emphasis = 20log[Non-transition/Transition]
 - = 20log[254mV/824mV]
 - = 20log[0.31]
 - =-10.2dB

9.1.1.4 Preshoot Measurement

1. Using cursors, measure pre-shoot amplitude, as shown in Figure 42.



FIGURE 42. MEASURED PRESHOOT AMPLITUDE (EXAMPLE 622MV)

- 2. Measure pre-shoot amplitude.
- 3. Calculate the pre-shoot: 20log[Pre-shoot/Non-transition]

```
=20log[622 mV/254mV]
=20log[2.44]
=7.8dB
```

- 4. Increase the Preshoot and Deemphasis levels to record the measured Preshoot and Deemphasis dB for 3.5 and -6.0, measured respectively. See Figure 43 and Figure 44.
- 5. Record the value.



FIGURE 43. BERTSCOPE SETUP #2



FIGURE 44. SCOPE SETUP AND MEASUREMENT #2

9.1.2 Launch Amplitude

The Launch Amplitude is calibrated for target minimum peak-to-peak amplitude of 800mVpp after combiner.

9.1.2.1 BERTScope Setup

- 1. Using the same TP1 Calibration Setup.
- 2. Set DPP to 0.0 for Preshoot and Deemphasis.
- 3. Set DPP Amplitude to 300mV.
- 4. Set Pattern to Clk/256.

9.1.2.2 Scope Setup and Measurement:

- 1. Using the same Setup, Scale Chan1 and Chan2 respectively.
- 2. Turn off Chan1 and Chan2.
- 3. Turn On Math1, set to ch1-ch2.
- 4. Set the Acquisition mode to Average of 256
- 5. Set Measure Amplitude of Math1.
- 6. Acquire waveform.
- 7. Read the MEAN value of amplitude measurement.
- 8. Tune the DPP Output until Amplitude measured in scope is 800mV.

9.1.3 Amplitude Equalization

Perform the equalization of low frequency and high frequency amplitude at TP1. This is done by adding small amount of Deemphasis of DPP, so that low frequency and high frequency have the same amount of amplitude after combiner.

- 1. Using the same setup of calibration for TP1, and same BERTScope and TekScope setting.
- 2. Tune the DPP Pre Cursor and Post Cursor so Deemphasis is 0.0dB.
- 3. Tune the DPP Post Cursor until the low frequency and high frequency component of amplitude is same level. See Figure 45.



 $Figure \ 45. \ Amplitude \ Equalization \ Setup$

4. Save the Post Cursor value.

9.1.4 RJ Calibration

- 1. Using a Clock pattern (1100), the RJ value of 0ps 5ps will be calibrated. (Both limits are RMS values.) RJ is used to adjust the Eye Width (EW) in Stress Jitter Test.
- 2. RJ target is 2ps (RMS).
- 3. Tektronix DPOJET is used as the calibration tool.

9.1.4.1 BERTScope Setup

- 1. Set the Generator to 8Gpbs.
- 2. Set the Sub-rate clock mode is Stressed Clock.
- 3. Set the RJ Enable.
- 4. Set the SJ Enable, Set the SJ Amplitude to 0.0mV. See Figure 46.



FIGURE 46. BERTSCOPE JITTER SETUP

5. Set the Pattern of generator to 1100.ram (1-1-0-0 pattern). See Figure 47.



FIGURE 47. BERTSCOPE PATTERN SETUP

9.1.4.2 DPP Setup

- 1. Set the DPP PreShoot and DeEmphasis using P4 preset (0.0db for both).
- 2. Set the post cursor and pre cursor based on equalized amplitude value recorded earlier.
- 3. Set DPP output that reflect 800mV amplitude that recorded earlier.

9.1.4.3 Scope Setup

1. Set the DPOJET Configure - > Clock Recovery to Constant Clock Mean.

alact	Measurement	Source(s)		Apply to All*	
Belect	RJ1	Math1	Edges	Method Apply Com	Recaic
	RJ661	Math1	Clock	Constant Clock - Mean V	
nfigure	PJ1	Math1	Recovery	Auto Calo	Single
	TIE1	Math1	RjDj	Auto Calc	
esults	Freq1	Math1	Eilbore	(First Acq)	Run
	TJ@BER1	Math1	Tillera		
Plots	RJ2	Math1	General	Every Acq	Show Plot
			Global	Advanced	1000

FIGURE 48. DPOJET CONFIGURE SETUP

2. Under RJDJ settings for clock signal.

Select R	Measurement N=661	Source(s)	Edges	Data	a Signal Settings	Apply to All	Recalc
D	J-δδ1	Math1	Clock			Apply	a
T	J@BER1	Math1	Recovery	Pattern Type	Pattern Length		Single
P	J1	Math1	RjDj	Repeating T	2UI (a)		- Dest
results			Filters				
Plots			General				
			Global				

FIGURE 49. RJDJ SETUP

3. On the Advance Panel, set the Nominal Data Rate to 8Gpbs.

File	e Edit V	ertical Digital	Horiz/Acq Trig	Display Cursors	Measure	Mask Math	MyScope	Analyze Utilities	s Help		Tek		X
M1													
1													
	HINKIN											it'n it n	TYC
						4 1 1 5 3							
							-						. –
MI										8			
1	i III III		Clock R	ecovery Advar	ced Setu	р							
				The	ese method: defeat	s may be used is normal clock	when unusua recovery met	lly high noise hods					
			N	ominal Data Rate									-
I			0	Auto Manu	al) —	Bit Rate 8.0000Gb/s	3						
Ĩ	M1 45.	9mV 4.0µs				-					50.0GS/s	20.0ps	/pt
	21M1 45.	9mV 4.0ns	2	nown Data Pattern							Single S	Seq	1
							Pattern I	File			oril 01, 2015	RL:2.0M	58:49
						C: (Users \Public \	Tektronix (Teka	pplications \DPOJE	I VPatterns V	vse			
	Jitter a	and Eye Diagra	ar —						6	~		Clear	×
	Select	Measure	m						OK		I*	Recalc	\triangleleft
	-	RJ1 RJ-δδ1		Math1	lock		Const	ant Clock – Me	an 🔻	Apply		0	
	Configu	PJ1	D.	Math1 Re	covery			Auto Cala				Single	
	-	TIE1	-	Math1	RjiDj			Auto Calc					
	Result	Freq1		Math1	Itore			First Acq)		6	Run	
	-	TJ@BER1		Math1	licia			Europy Acre				0	
	Plots	RJ2		Math1 G	neral			Every Acq		-	SI	ally	
	Bonart	2		G	lobal					Advance	9	unn	
	Report	2			6	Copies these of	lock recovery	settings to other	r measurements				

FIGURE 50. SCOPE ADVANCED SETUP

4. Set the Horizontal mode to Manual, set record length to 2M.



FIGURE 51. SCOPE RECORD LENGTH SETUP

5. Clear the result. Run Single.



FIGURE 52. SCOPE WAVEFORM CAPTURE

6. Read the measured RJ1.

7. Tune the BertScope RJ value.



FIGURE 53. BERTSCOPE RJ CAPTURE

8. The target measured value for RJ: 2ps RMS and 3ps RMS.

9.1.5 SJ Calibration

There are four SJ (Sweep Jitter) frequencies required: 30KHz, 1MHz, 10MHz and 100MHz. SJ needs to be calibrated (with 1100 pattern) for all cases in the proper way.

 TABLE 4. STRESSED JITTER TESTS

Frequency		
30KHz		
1MHz		
10MHz		
100MHz	0.1	UI PP



Stressed Jitter Test:

T _{RX-ST-SJ-8G}	Sinusoidal Jitter	0.1 - 1.0	UI PP	See Figure 4-74 Measured at TP1. See Note 3.
--------------------------	-------------------	-----------	-------	---

The Stressed Jitter test requires the test to pass each and every frequency, with its respective SJ amplitude at 30KHz, 1MHz, 10MHz and 100MHz.



FIGURE 54. SWEEP JITTER RANGE AND MASK

Using this same setup at each frequency, make the measurement.

9.1.5.1 Calibrate Sweep Jitter at 30KHz.

1. On BERTScope, Enable *Phase Modulator* and Set *PM Frequency* to 30KHz and *PM Devn: 1UI*.



FIGURE 55. SWEEP JITTER BERTSCOPE SETUP AT 30KHz

- 2. On the BERTScope, using DPOJET, measure PJ1. Note, for this measurement the DPOJET Clock Recovery Method should be set to Constant Clock Mean so as to not filter the low frequency jitter modulation that is to be verified.
- *3.* Read the PJ1 measurement. It is in units of seconds. Convert to UI.

9.1.5.2 Calibrate Sweep Jitter at 1MHz, 10MHz, 100MHz

1. Set Sine Jitter initially to 10% UI.



FIGURE 56. SWEEP JITTER BERTSCOPE SETUP AT 1MHz-100MHz

1. Measure SJ using DPOJET.



FIGURE 57. SWEEP JITTER DPOJET MEASUREMENT AT 1MHz-100MHz

- 2. Read the PJ1 value.
- 3. Again, note value of SJ on BERTScope needed to generate 10% SJ at reference point.
- 4. Calibration for 1MHz, 10MHz and 100MHz will need to set the SJ Frequency and SJ Amplitude instead of PM.



FIGURE 58. CALIBRATION AT 1MHz-100MHz



FIGURE 59. SWEEP JITTER DPOJET MEASUREMENT AT 1MHz-100MHz

9.2 Channel Calibration Tests (TP2)

9.2.1 Channel Calibration Insertion Loss

PCIe Gen3 defines 3 types of calibration channel.

- 1. None
- 2. Short
- 3. Long

Defined by Figure 60, each channel insertion loss must meet the mask depending on its channel type. Variable and programmable ISI injector is needed to simulate the trace length to achieve the target loss for each channel.



FIGURE 60. CHANNEL INSERTION LOSS MASK BY CHANNEL TYPE

Insertion loss is measured by differentiating step response, and doing the FFT of the resulting impulse response. The Seasim application provides the method to calculation the insertion loss given the step response.

9.2.1.1 BERTScope Setup

- 1. Set BERTScope Set Pattern to clk/256.
- 2. Set DPP Set Deemphasis and Preshoot to P4 with post cursor and pre cursor for equalization of amplitude recorded earlier.
- 3. Set DPP output that reflects the 800mV amplitude that was recorded earlier.
- 4. Disable Rj.
- 5. Disable Sj.

9.2.1.2 ISI Setup

1. Open the Artek ISI application.

2. Set the ISI % to 0.0.

	_	0.0
0%	50%	100%
Com port no.		Close

FIGURE 61. ISI SETUP

9.2.1.3 Scope Setup

- 1. Turn On Ch1 and Ch2, scale ch1 and ch2 correctly.
- 2. Turn Off ch1 and ch2
- 3. Turn ON Math1, set ch1-ch2. Scale correctly.
- 4. Setup Trigger A Event to Edge, source to chan1,
- 5. Setup Trigger A-B Event with Acquisition Delay to 4ns.

A Event	Trigger Type Edge	Source	-	Coupling		
A->B Seq	Select	Ch1 🕞	т —	DC	Force	
B Event	Mark All Trigger		1	Slope	Ingger	
Options	Events in Record	Select	Level	1 🕖		
		Set to 50%				
		F				
	Settings			X		

FIGURE 62 SCOPE SETUP #1



FIGURE 63 SCOPE SETUP #2

6. Setup Acquisition Mode to Average of 2048 Waveforms.



FIGURE 64 SCOPE ACQUISITION MODE SETUP

7. Run Single and capture measurement.

File	Edit Vertica	l Digital	Horiz/Acq Trig	Display	Cursors Mea	sure Mask	Math MySce	ope	Analyze	Utilities He	Ip 💽		Tek		X
		1000							لنحدز المنابل			معن <u>معن المان معن معن المعن ال</u>		T T	
				N		1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 -									ю ю. —
-															
-												a 10 m 10 m	11. 11. <u>10</u>	a. a.	
-												2	Dof Doint	-	-
M1->							i						Rei Point		
													50.0%		
													Horiz Dela	V D	
												1 00 00 e			
													4.0ns		
	1997 - 1997 - 1997 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -	· · · · · · · ·													· · · ·
					1 1 1 1	1 1 1		1 1							11.
	60.0mV	2.0ns							A' C1	● / 4.8mV		2.0ns/div	50.0GS/s	20.0ps	s/pt
		Value	Mean	Min	Max	St Dev	Count	Info	Hora	z Diy: 4.0h	5	Stopped	Single Se	q	
	Min*	-279.9m	V -279.89376	m -279.9m	-279.9m	0.0	1.0					2 048 acqs	F	RL:1.0k	
	Max Max	275.7mV	275.71252	n 275.7m	275.7m	0.0	1.0					Auto Apr	il 01, 2015	05:	06:31
	Mean	101.5mV	101.45004	n 101.5m	101.5m	0.0	1.0								
	M Pk-Pk	555.6mV	555.60628	n <u>555.6</u> m	555.6m	0.0	1.0	,							
11-	i i	Trigger -	A->B Seque	nce							_	A:Edge -+ Acg	After Delay	1	X
		ingger	ne b ocque			1				1		11000			1
	A Event		Aonhr		Horizont			_				Trigger Re	set		N
	A SP See		Aonly		Delay Mo	ode		R	ef Point						~
	N=D acd		(A only)		On	Before	siton -		50.0%	a		Туре	Transition		
	B Event		A					1		rigger	Trans	sition 🔻 Ris	sing 🔻		
			A then B			1		1	4.8	mV					-
	Options					i.t		nr			5	Source	Threshold		
						E		Ч			Ch 1		0.0V		
		rng Ane	er time i tig or	i nun Event			1000								
		Time) (ntl	n event			- Acqu	isition	Delay		R	leset A->B seque	nce after		
							-	4.0115				transition as set	above		
			-	_											

FIGURE 65 CAPTURE MEASUREMENT

- 8. Save the Waveform to .DAT format.
- 9. Modify the .dat format to Seasim compatible waveform with name ending _vict.rfstep1.
- 10. The _vict.rfstep1 format is consist of **time**[SPACE]**Voltage_level**[New Line].
- 11. Copy the _vict.rfstep1 step response to \step_response folder.

12. Launch Seasim_GUI.pyw.

File	Inc	lud	e								
Mai	n	S-F	Parameters] Ji	tter/Noise	Equalizers	Step Res	ponses	Configuration	Sweep		
Use	touc	hsto	one files			Plot S-pa	rameter	rs			
Plot	TDR					Plot Step	s		-		
Stati	stica	I Ey	e	-		Measure	EIEOS				
Mea	sure	PS:	21TX			Show plo	ots		-		
Job	nam	е		TestSG							
Step	res	pon	se relative pati	h step_res	sponses						
Base	nar	ne f	for step	RJ0ps_L	V600mV						E
S-parameter relative path S-parameters							E				
	#	N	Touchstone files		In	put Ports	Outpu	ut Ports			1
1			Gen3 package	model							
2		1	s12p_Txpkg_l	542010_b.	12p [1,2	3,5,7,9,11]	[2,4,6,	8,10,12]			
3		1	s12p_pin2pin	642010_b	s12p [1,3	3,5,7,9,11]	[2,4,6,	8,10,12]			
4	-	1	s12p_Rx_pkg_	642010_b	.s12p [1,3	,5,7,9,11]	[2,4,6,	8,10,12]			
5		1	PCIe3RxPacka	geModel.s	2p [1]		[2]				
6											
7											~
Unit	inter	val	in secs	125e-12	# Tim	e in secs					
Tota	I nui	mbe	er of channels	1							
-					_	-				-	

FIGURE 66 SAVE THE WAVEFORM

- 13. Change the file name Base name Step to the file name saved and modified. 14. Click Run.

15. Seasim will output graph indicating the insertion loss.



FIGURE 67 SEASIM INSERTION LOSS OUTPUT GRAPH

- 16. Insertion loss at 4GHz is -9dB for sample above.
- 17. Increase the ISI % then re capture the waveform, save, modify and run Seasim.
- 18. Ensure the insertion loss is between the PCIe Gen3 specs for respective channel type.



PCI EXPRESS BASE SPECIFICATION, REV. 3.0

FIGURE 68 SPECIFICATION MASK



FIGURE 69 INSERTION LOSS AT 27.5% ISI (-16.9DB)



FIGURE 70 INSERTION LOSS AT 30.% ISI (-17.9DB)



FIGURE 71 INSERTION LOSS AT 32.5% ISI (-18.9DB) WITHIN TARGET



FIGURE 72 INSERTION LOSS CALIBRATION FOR LONG CHANNEL – IL FALLS BETWEEN REQUIRED MASK

9.2.2 Channel Calibration Differential Mode Sinusoidal Interference

9.2.2.1 BERTScope Setup

1. Set ALL ZERO Pattern.



FIGURE 73 BERTSCOPE SETUP FOR ALL ZERO PATTERN

- 2. Set all Jitter to 0mV amplitude.
- 3. Enable the SINE INTERFERENCE.
- 4. Set the Frequency to 2.1GHz.
- 5. Set to External.



FIGURE 74 BERTSCOPE SETUP #2

6. Set the Sine Interference Amplitude to 100mV.

9.2.2.2 ISI Setup

1. Set the Artek ISI % to calibrated channel type.

C	%
	1009

FIGURE 75 ARTEK ISI SETUP

9.2.2.3 Scope Setup

- 1. Set Acquisition Average to 256.
- 2. Scale Ch1 and Ch2 accordingly.
- 3. Turn on MATH1, ch1-ch2, scale accordingly.
- 4. Measure Peak to Peak of Math1.
- 5. Run Single.
- 6. Obtain the MEAN value of math1 peak to peak.
- 7. Tune the Sine Interference Amplitude so measured value is 16mV.



FIGURE 76 SCOPE MEASUREMENT

9.2.3 Channel Calibration AC Common Mode Sinusoidal Interference

9.2.3.1 BERTScope Setup

- 1. Remain ALL ZERO Pattern.
- 2. Set the SINE Interference amplitude to 0mV.

9.2.3.2 Setup AFG

- 1. Enable the AFG output 1.
- 2. Set the Output Mode to SINE wave.
- 3. Set the SINE Wave frequency to 120MHz.
- 4. Set the Output1 Amplitude to 1V.

9.2.3.3 Scope Setup

- 1. Scale Ch1 and Ch2.
- 2. Set MATH1 to ch1+ch2.Scale MATH1.
- 3. Turn OFF Ch1 and CH2.
- 4. Set Acquisition to Average 256.



FIGURE 77 SCOPE MEASUREMENT

- 5. Tune the AFG Amplitude.
- 6. Target CM:

150mV for Long Channel

250mV for Short and None Channel

9.3 Calibration at TP2P

Two distinct tests are utilized to test a receiver: one for its minimum eye height (voltage), and another for its minimum eye width (jitter). The procedures for calibrating the stressed eye are similar, although the number and magnitude of signal impairment sources varies between the two tests.

9.3.1 TP2P Stressed Voltage Calibration

The configuration for calibrating a stressed voltage eye for Rx testing is shown below where the calibration procedure is performed for all three calibration/breakout channel combinations. Rj and Sj are added as defined in below and common mode and differential mode noise sources are added simultaneously.



Figure 4-71: Setup for Calibrating the Stressed Voltage Eye

Figure 78 Setup for Calculating the Stressed Voltage Eye

Symbol	Parameter	Limits at 8.0 GT/s	Units	Comments
Vrx-launch-8g	Generator launch voltage	800	mVPP	Measured at TP1 Figure 4-65. $V_{RX-LAUNCH-8G}$ may be adjusted if necessary to yield the proper EH as long as the outside eye voltage at TP2 does not exceed 1300 mVPP.
T _{RX-UI-8G}	Unit Interval	125.00	ps	Nominal value is sufficient for Rx tolerancing. Value does not account for SSC.
V _{RX-SV-8G}	Eye height at TP2P	25 (-20 dB channel) 50 (-12 dB channel) 200 (-3 dB channel)	mVPP	Eye height @ BER=10 ⁻¹² . Notes 1,2.
T _{RX-SV-8G}	Eye width at TP2P	0.3 to 0.35	UI	Eye width at BER=10 ⁻¹² . Note 2
V _{RX-SV-DIFF-8G}	Differential mode interference	14 or greater	mVPP	Adjusted to set EH. Frequency = 2.10 GHz. Note 3.
V _{RX-SV-CM-8G}	Rx AC Common mode voltage at TP2P	150 (EH < 100 mVPP) 250 (EH ≥ 100 mVPP)	mVPP	Defined for a single tone at 120 MHz. Note 3.
T _{RX-SV-SJ-8G}	Sinusoidal Jitter at 100 MHz	0.1	UI PP	Fixed at 100 MHz. Note 4.
T _{RX-SVRJ-8G}	Random Jitter	2.0	ps RMS	Rj spectrally flat before filtering. Notes 4,5.
V _{RX-MAX-SE-SW}	Max single- ended swing	±300	mVP	Note 6.

FIGURE 79 STRESSED VOLTAGE EYE PARAMETERS

10

Eye width and eye height are defined after applying post processing and are defined at TP2P. The long calibration channel utilizes both CTLE and DFE, while the medium and short channels calibration channels use CTLE only.

EH is set by adjusting the amount of differential noise until the value defined by VRX-SV-8G is obtained. If it is not possible to maintain a sufficient eye width by adjusting only the differential noise, it is acceptable to inject less differential noise and adjust the generator launch voltage.

Seasim is used to post process the receiver eye at TP2P.

In this context, Rj, Sj, DM-SI source are input to Seasim. While CM SI are combined with clk/256 pattern source from BERT and captured in Scope.

9.3.1.1 BERTScope Setup

- 1. Set BERTScope Pattern to clk/256
- 2. Turn Off Rj, Sj, DM-Si at BERTScope.
- 3. Set DPP Ouput to 800mV Amplitude calibrated earlier.
- 4. Set DPP DeEmphasis and Preshoot. Use "Preset 4 for Short and None channel. Use Preset 7 for Long channel.

9.3.1.2 AFG Setup

1. Turn Off AFG

9.3.1.3 Scope Setup

- 1. Setup Trigger A Event to Edge, source to chan1,
- 2. Setup Trigger A-B Event with Acquisition Delay to 4ns.



FIGURE 80 SCOPE SETUP

- 1. Scale Ch1 and Ch2, Math1 (ch1-ch2)
- 2. Set Acquisition to Average to 2048
- 3. Acquire the Waveform.
- 4. Save the Waveform.

ile Edit Vertical Digital	Horiz/Acq Trig Display	Cursors Measure Mask	Math MyScope	Analyze Utilities Help	Tek 📃 🔀
	الارتعادي كالمرك			يستعربها أعربهم متبعيتها أهريه	
				· · · · · · · · · · · · · · · · · · ·	
5					
5		1.00			
5					
5					
5					
127mV 2.0ns				M	2.0ns/div 50.0GS/s 20.0ps/pt
Val	IO Moan Mi	n Max St Dou	Count Info	Horz Dly: 4.0ns	Stopped
Min* -533.1	mV -533.05316m -533.1	m -533.1m 0.0	1.0		3 000 acqs RL:1.0k
Max 529.1m	1V 529.11633m 529.1n	n 529.1m 0.0	1.0		Man April 02, 2015 20:55:44
	177 00070				
Pk-Pk 1.062V	V 177.66976m 177.7n 1.0621695 1.062	1.062 0.0	1.0		

FIGURE 81 ACQUIRED WAVEFORM

5. Modify Waveform to Seasim compatible format.



FIGURE 82 APPLY SEASIM

- 6. Apply the Rx Behavioral Package
 - a) Rx Behavioral Package (in S2P/S4P) file.
 - b) CTLE /DFE and CDR can be simulated in Seasim.

- c) Rx Package model is convoluted externally with Step response before input to Seasim
- d) Step response is convert to Frequency domain, then multiply the magnitude with s2p S21 magnitude and phase corresponding to its frequency range.
- e) It can be realized using python script.
- f) A comparison of original frequency response (red), and the after application of s2p (purple), showing the s2p Rx package s21 graph as a green line.



FIGURE 83 GRAPHICAL COMPARISON OF ORIGINAL AND AFTER-APPLICATION RESPONSE g) Step response before (red) and after (purple).



FIGURE 84 GRAPHICAL STEP RESPONSE COMPARISON

- 7. Run Seasim:
 - a) Set the Base Name for Step to filename saved.

b) Check the options on top save as picture below.

			Seasin	n 0.54 - test	example	e.sea (ri	oot_dir:	C:\Python2	6\seasim)	- 6	×
File	Inc	clud	e								
Mai	n	S-I	Parameters Jit	ter/Noise Equ	alizers	Step Res	ponses	Configuratio	n Sweep		
Use Plot Stat Mea	touc TDR istica	al E	one files ye 21TX			Plot S-pa Plot Step Measure Show plo	erameter IS EIEOS IDts	5			
Job	nam	e		TestSG							
Step	res	pon	se relative path	step_respons	ses						
Base	e nar	me	for step	newStepRes	ponse						
S-pa	aram	ete	r relative path	S-parameter	s						51
	#	N	Touchs	tone files	Input	t Ports	Outpu	It Ports			^
1		1	Gen3 package	model		_					
2		1	s12p_Txpkg_6	42010_b.s12p	(1,3,5,	7,9,11]	[2,4,6,	8,10,12]			
3		1	s12p_pin2pin_	642010_b.s12	0 [1,3,5,	7,9,11]	[2,4,6,	8,10,12]			
4	2	1	s12p_Rx_pkg_	642010_b.s12p	[1,3,5,	7,9,11]	[2,4,6,	8,10,12]			~
Unit	inte	rval	in secs	125e-12	# Time i	n secs					
Tota	Total number of channels			1							
					Run	1.1				S	top
	-	-	dia ne an	d and the state	1 - N P	100 100		4 754			
ehp ew: lane pwr lfrj: UTJ < </td <td>k=1 =0.5 es=1 j=1. =1.5 =35 Meas</td> <td>29.8 140 nu .00p 5ps .85p sure - se</td> <td>amV (ehc=121.(I, 64.2ps (ewof =80 cb=6 ps pwddj=10.0p lfddj=7.0ps os d CDF>> delta asaim finished</td> <td>time: 0.882 tir</td> <td>nestamp:</td> <td>UI) 5.636</td> <td>iestamb</td> <td>. 4./ 54</td> <td></td> <td></td> <td></td>	k=1 =0.5 es=1 j=1. =1.5 =35 Meas	29.8 140 nu .00p 5ps .85p sure - se	amV (ehc=121.(I, 64.2ps (ewof =80 cb=6 ps pwddj=10.0p lfddj=7.0ps os d CDF>> delta asaim finished	time: 0.882 tir	nestamp:	UI) 5.636	iestamb	. 4./ 54			
											~

FIGURE 85 SEASIM BASE NAME SETUP

- c) On Jitter Noise tab:
 - i) Set the Corresponding Jitter value for Rj, Sj, DM-SI.
 - ii) DM-SI value need to tuned and vary to achieve EH.
 - iii) Set DM-SI to 0mV for start.
 - iv) Set LF Random Jitter = Rj (2ps).
 - v) Set LR Uniformly distributed Jitter = Sj (0.1UI).

vi) Set LF Uniformly Distributed Voltage Noise = DM-SI 14mV or more.

File Include						
Main S-Parameters Jitter/Noise	Equalizers Step Responses Configuration Sweep					
Use seconds for Jitter	V					
Pulse Width Random jitter	0.0e-12 # PWJ RJ (1.414*jit_hfrj)					
Pulse Width Dual-Dirac jitter	0.0e-12 # PWJ pk-pk dual-dirac jitter (2*jit_hfddj)					
Edge RJ Nui earlier than cursor	0.0e-12 # nui-cycle RJ					
LF Random jitter	2e-12 # Gaussian sigma post channel jitter					
LF Dual-Dirac jitter	0.0 # dual-dirac post channel jitter					
LF Uniformly distributed jitter	1.25e-11					
LF Random Voltage noise	0.0					
LF Uniformly distributed Voltage noise	14e-3					

FIGURE 86 SEASIM JITTER/NOISE SETUP

- d) On Equalizer tab:
 - i) Set the DFE taps and max Magnitude.
 - ii) If Long channel set to [0.000] (Disable DFE)
 - iii) If Short and None, set to [0.030], Enable with Max of 30mV.

	Sea	sim-0.54 - te	st_examp	le.sea (root_dir: C:\Python26\seasim) 🛛 🗕 🔜					
File In	nclude								
Main S-Parameters Jitter/Noise Equalit			qualizers	zers Step Responses Configuration Sweep					
Adapta	tion FOM		area	a v					
Include	xtalk during ada	ptation							
Tx pre-	shoot search spa	ace (priority) (d	B) []						
Tx de-e	emphasis search	space (priority)	(dB) []						
Tx coef	ficient search sp	ace	24	24 # Coefficent space size					
LEQ1 DC gain search space (dB)				range(-12,-5) # DC gain of CTLE in dB					
LEQ1 pole search space (Hz)			[2e9	[2e9] # CTLE fixed pole location					
LEQ2 DC gain search space (dB)				[0]					
LEQ2 p	ole search space	(Hz)	[0]	[0]					
Max Tx EQ boost (dB)				8.0 # Maximum Tx EQ boost in dB for Cspace search					
DFE tap	os and max magr	nitude (V)	[0.0]	[0.030] # Number and dynamic range of DFE taps					
If no ac	aptation EQ can	be explicitly set	below						
Tx pre-shoot (priority) (dB)			0.0	0.0					
Tx de-e	emphasis (priority	y) (dB)	0.0	0.0					
				run .					

FIGURE 87 SEASIM EQUALIZER SETUP

e) Run Simulation.

8. Simulated Eye Diagram will be created, with its calculated EH and EW at BER-12 based on jitter input.



FIGURE 88 SEASIM SIMULATED EYE DIAGRAM #1

9. Observe the EH and EW.

10. Change the DM-SI value to 15mV and run simulation again.



Figure 89 Seasim Simulated Eye Diagram #2

11. Change the DM-SI value to 16mV and run simulation again.



FIGURE 90 SEASIM SIMULATED EYE DIAGRAM #3

12. Calibrate until EH is obtained.

(*) If EW range cannot be achieved, Increase the Amplitude from 800mV to 900mV and perform the Stress Voltage calibration again until EH and EW are obtained.

9.3.2 Stressed Jitter Calibration (For Long Channel Only)

The stressed jitter calibration procedure is similar to that of stressed voltage. Only the long calibration channel (-20 dB) is used. Note that the same post processing scripts are applied identically as they are for the stressed voltage eye case. Eye width is fine-tuned by making adjustments to the Rj source, while EH may be adjusted by varying the launch voltage at the generator.



Figure 4-73: Layout for Calibrating the Stressed Jitter Eye

Symbol	Parameter	Limits at 8.0 GT/s	Units	Comments
V _{RX-LAUNCH-}	Generator launch voltage	800 (nominal)	mVPP	Measured at TP1, see Figure 4-65. See Note 1.
T _{RX-UI-8G}	Unit Interval	125.00	ps	Nominal value is sufficient for Rx tolerancing. Value does not account for SSC.
V _{RX-ST-8G}	Eye height at TP2P	25 (min) 35 (max)	mVPP	At BER=10 ⁻¹² . See Note 2.
T _{RX-ST-8G}	Eye width at TP2P	0.30	UI	At BER=10 ⁻¹² . See Note 2.
T _{RX-ST-SJ-8G}	Sinusoidal Jitter	0.1 – 1.0	UI PP	See Figure 4-74 Measured at TP1. See Note 3.
T _{RX-ST-RJ-8G}	Random Jitter	3.0	ps RMS	Rj spectrally flat before filtering. Measured at TP1. See Note 4.

Table 4-23: Stressed Jitter Eye Parameters

FIGURE 92 SPECIFICATION FOR LONG CHANNEL CALIBRATION

9.3.2.1 BERTScope Setup

- 1. Set BERTScope Pattern to clk/256
- 2. Turn Off Rj, Sj, DM-Si at BERTScope.
- 3. Set DPP Output to 800mV Amplitude calibrated earlier.
- 4. Set DPP Deemphasis and Preshoot to Preset 7 for Short channel. Preset 4 for other channel Type.
- 5. Turn Off AFG.

9.3.2.2 Scope Setup

- 1. Setup Trigger A Event to Edge, source to chan1,
- 2. Setup Trigger A-B Event with Acquisition Delay to 4ns.



FIGURE 93 SCOPE SETUP

- 3. Scale Ch1 and Ch2, Math1 (ch1-ch2).
- 4. Set Acquisition to Average to 2048.
- 5. Acquire Waveform.
- 6. Save Waveform.
- 7. Modify Waveform to Seasim compatible format.

9.3.2.3 Apply Rx Behavioral Package

- 1. Run Seasim:
 - a) Set the Base Name for Step to filename saved.
 - b) Check the options on top save, as shown in Figure 94.



FIGURE 94 SEASIM MAIN SETUP

- c) On Jitter Noise tab.
 - i) Set the Corresponding Jitter value for Rj, Sj.
 - ii) Rj value need to tuned and vary to achieve EW.
 - iii) Set LF Random Jitter = Rj (3ps or more).
 - iv) Set LR Uniformly distributed Jitter = Sj (0.1UI).
 - v) Set LF Uniformly Distributed Voltage Noise = 0.0mV.

File Ir	nclude								
Main	S-Parameters	Jitter/Noise	Equalizers	Step Responses	Configuration	Sweep			
Use sec	conds for Jitter		•						
Pulse V	Vidth Random jitt	er	0.0e-12	0.0e-12 # PWJ RJ (1.414*jit_hfrj)					
Pulse V	Vidth Dual-Dirac j	itter	0.0e-12	0.0e-12 # PWJ pk-pk dual-dirac jitter (2*jit_hfddj)					
Edge RJ Nui earlier than cursor			0.0e-12 # nui-cycle RJ						
LF Random jitter			3e-12 # Gaussian sigma post channel jitter						
LF Dual-Dirac jitter			0.0 # dual-dirac post channel jitter						
LF Uniformly distributed jitter			1.25e-11						
LF Random Voltage noise			0.0						
LF Uniformly distributed Voltage noise			0e-3	0e-3					

FIGURE 95 SEASIM JITTER/NOISE SETUP
- d) Equalizer tab:
 - i) Set the DFE taps and max Magnitude.ii) Set to [0.030].

File Include							
Main S-Parameters Jitter/Noise Equaliz	Zers Step Responses Configuration Sweep						
Adaptation FOM	area 🗸						
Include xtalk during adaptation							
Tx pre-shoot search space (priority) (dB)							
Tx de-emphasis search space (priority) (dB)	0						
Tx coefficient search space	24 # Coefficent space size						
LEQ1 DC gain search space (dB)	range(-12,-5) # DC gain of CTLE in dB						
LEQ1 pole search space (Hz)	[2e9] # CTLE fixed pole location						
LEQ2 DC gain search space (dB)	[0]						
LEQ2 pole search space (Hz)	[0]						
Max Tx EQ boost (dB)	8.0 # Maximum Tx EQ boost in dB for Cspace search						
DFE taps and max magnitude (V)	[0.030] # Number and dynamic range of DFE taps						
If no adaptation EQ can be explicitly set below	W						
Tx pre-shoot (priority) (dB)	0.0						
Tx de-emphasis (priority) (dB)	0.0						
Tx EQ FIR coefficients	[1]						
LEQ1 DC gain (dB)	-10						
LEQ1 pole (Hz)	2e9						
LEQ1 zero (Hz) (provides gain if not 0)	0.0						
LEQ2 DC gain (dB)	0.0						
LEQ2 pole (Hz)	0.0						
LEQ2 zero (Hz) (provides gain if not 0)	0.0						
Rx bandwidth (Hz) (1st pole)	8e9 # HF roll-off of equalizer						
Rx bandwidth (Hz) (2nd pole)	0.0						

FIGURE 96 SEASIM EQUALIZER SETUP

e) Run Simulation.

2. Simulated Eye Diagram will be created with its calculated EH and EW at BER-12 based on jitter input.



FIGURE 97 WAVEFORM #1

- 3. Observe the EH and EW.
- 4. Change the Rj value and run simulation again.
- 5. Calibrate until EW is obtained.

(*) If EH range cannot be achieved, Increase the Amplitude from 800mV to 900mV and perform the Stress Jitter calibration again until EH and EW are obtained.

9.4 Receiver Test

9.4.1 Equipment Setup



FIGURE 98 RECEIVER TEST EQUIPMENT SETUP

9.4.1.1 Connection Steps

- 1. Connect BERTScope Data(+) to DPP.
- 2. Connect BERTScope Clk Out to DPP.
- 3. Connect DPP Data(+) out to Combiner In.
- 4. Connect DPP Data(-) out to Combiner In.
- 5. Connect AFG Output1 to Combiner CM-IN.
- 6. Connect BERTScope (real panel) SI-out to Combiner DM In.
- 7. Connect Combiner Data Out to Artek Box.
- 8. Connect Artek Box Out to DUT In.
- 9. Connect DUT Tx Out to Clock Recovery CR125A Data In.
- 10. Connect CR125A Data out to BERTScope Detector Data In.
- 11. Connect CR125A Subrate Clock Out to BERTScope Detector Clock In.
- 12. Connect the External Clock from BERTScope to DUT as Ref Clk (100MHz).

9.4.2 Stressed Voltage Receiver Test

Once a calibrated EH and EW have been obtained, the cables are moved to connect the Rx DUT to the far end of calibration channel. The Tx equalization is then optimized as it was for the stressed voltage eye with the assumption that the DUT Rx will also optimize its equalization. Sj is set to an initial value that permits the receiver CDR to achieve lock.

9.4.2.1 Configure BERTScope

- 1. Set Generator to 8Gpbs.
- 2. Set the Pattern to PCIe_8G_BruteFor.RAM.



FIGURE 99 RECEIVER TEST CONFIGURE BERTSCOPE

9.4.2.2 Configure for Stressed Jitter

- 1. Set the Calibrated SJ for 0.1UI at 100MHz.
- 2. Set the Calibrated Rj for 2ps(RMS).
- 3. Set the Calibrated Sine Interference Amplitude that is calibrated to achieve EH and EW (DM-SI).
- 4. Set the Sine Interference Frequency to 2.1GHz.
- 5. Set the Sine Interference mode to External.
- 6. Set the DPP Output to calibrated amplitude to achieve EH and EW.



FIGURE 100 RECEIVER TEST CONFIGURE FOR STRESSED JITTER

- 7. Configure ISI by setting Artek ISI % value to calibrated channel Type.
- 8. Configure AFG:
 - a) Set Output1 of AFG ON
 - b) Set Output1 Mode to Sine Wave
 - c) Set Sine Wave Frequency to 120MHz
 - d) Set the Sine Wave Amplitude to Calibrated value.
- 9. Setup the BERTScope Detector:
 - a) Click the Auto Align



FIGURE 101 RECEIVER TEST CONFIGURE BERTSCOPE DETECTOR

9.4.2.3 Bit Error Rate Test

- 1. With the DUT in loopback mode, and BERTScope synchronize with pattern.
- 2. Compliance test may begin.
- 3. Click the Reset Result.
- 4. Click the RUN.
- 5. Let the Detector Run, stop when the BITs is more than 1xE12.
- 6. Read the Error value.
- 7. If the error is zero (0), then the test passes.

DETECTOR	T Inject Error	Auto Align Manua Resyn	Reset Results	View					
CLK RECOVERY LOCKED SO Ohms AC	DELAY 142.8 ps	00.00 Mbit/s	DET TRIGGER	Back					
Loop BW: 10.000 MHz Peaking: 2.09 dB	oop BW: 10,000 MHz Yeaking: 2.09 dB Pattern: User								
Atten: 0.0 dB Thish: 7.0 mV	Det Aut Syn Use File	ected: User o Resync ic Loss Thresh: 128 r Pattern Mode: Shift : PCIe_8G_BruteFor		Run					
START	Syn	rds: 1 hbol Filtering: OFF		Print					
CAPTURE	DI	TECTOR RESULTS							
Disabled	Bits	70,356,	998,912	Config					
	Errors		0						
	BER	0	.00E+00	Help					
BLANK	Resyncs		000005						
No Resync Ignore Bits	Error Free	7.04E+10,0	00:00:05	Shutdown					
Gen: User 8,000.00 Mbit/s De	t: User 8,000.00 Mbit/	s BER: 0.00E-	+00	Local					

FIGURE 102 RECEIVER TEST PERFORM BER TEST

9.4.3 Stressed Jitter Receiver Test (100MHz)

9.4.3.1 Configure BERTScope

- 1. Set Generator to 8Gpbs.
- 2. Set the Pattern to PCIe_8G_BruteFor.RAM.



FIGURE 103 RECEIVER STRESSED JITTER TEST BERTSCOPE SETUP

9.4.3.2 Configure for Stressed Jitter at 100MHz

- 1. Set the Calibrated SJ for 0.1UI at 100MHz.
- 2. Set the Calibrated RJ that is calibrated during Stressed Jitter Calibration that achieved EW and EH.
- 3. Set the Calibrated Sine Interference to 0mV.
- 4. Set the DPP Output to calibrated amplitude to achieve EH and EW.



FIGURE 104 RECEIVER STRESSED JITTER TEST BERTSCOPE SETUP

- 5. Configure ISI by setting Artek ISI % value to calibrated channel Type.
- 6. Configure AFG by setting Output1 of AFG OF.
- 7. Setup the BERTScope Detector by clicking on Auto Align.



FIGURE 105 RECEIVER STRESSED JITTER TEST BERTSCOPE DETECTOR

9.4.3.3 Bit Error Rate Test

- 1. With the DUT in loopback mode, and BERTScope synchronize with pattern.
- 2. Compliance test may begin.
- 3. Click the Reset Result.
- 4. Click the RUN.
- 5. Let the Detector Run, stop when the BITs is more than 1xE12.
- 6. Read the Error value.
- 7. It is Pass if error is 0.

DETECTOR	Inject	Auto Manua Alian Resynd	Reset				
				View			
CLK RECOVERY LOCKED 8.000 GHz 50 Ohms AC	DELAY 142.8 ps	00.00 Mbit/s	DET TRIGGER Pattern Cycle	Back			
Loop BW: 10.000 MHz Peaking: 2.09 dB	E Pat	ERROR DETECTOR Pattern: User					
Atten: 0.0 dB	Aut Syr Use	ected: User o Resync ic Loss Thresh: 128 ir Pattern Mode: Shift		Run			
50 Ohms to 0 mV	Wo	rds: 1 hbol Filtering: OFF		Print			
CAPTURE	DI	TECTOR RESULTS		Config			
Disabled	Bits	70,356,	998,912	Coming			
	BER	0.	00E+00	Help			
BLANK	Elapsed Time		0:00:05				
No Resync Ignore Bits	Error Free	7.04E+10,0	0:00:05	Shutdown			
Gen: User 8,000.00 Mbit/s	: User 8,000.00 Mbit/	s BER: 0.00E+		Local			

FIGURE 106 RECEIVER STRESSED JITTER PERFORM BER TEST

10 PVT Automation

Granite River provides software to support repeated testing within sequences of parameter values, which are applied to the DUT during the tests.

10.1 Available Parameters

Table 5 lists the parameters which can be controlled by the PVT Automation software. Up to eight values may be specified for each parameter.

Symbol	Parameter	Units
RJ	Random Jitter	Picoseconds
ISI	Inter Symbol Interference	Per cent of UI
SJ	Sinusoidal Jitter	Picoseconds
Amplitude	Launch Voltage	Millivolts, peak-to-peak
СМ	Common Mode (noise source)	
DM	Differential Mode (noise source)	

 TABLE 5. AVAILABLE PARAMETERS

10.2 Applicable Tests

Table 6 lists the tests which can be controlled by the PVT Automation software. PVT parameters have no effect on other tests in the suite.

TABLE 6. APPLICABLE TESTS

Test Title
Stress Voltage Sweep Test (none)
Stress Voltage Sweep Test (short)
Stress Voltage Sweep Test (long)

Stress Jitter Sweep Test (long)

10.3 Setting up PVT Value Sequences

1. Select the PVT Configuration icon on the toolbar. See Figure 107.



FIGURE 107 SELECT PVT CONFIGURATION

2. Add a parameter to the selected test by selecting "Add Condition". See Figure 108, which selects 'SJ' as the new condition group. No drop-down menu of allowed parameter names is provided. Refer to Table 5. A short description may be provided. This description, and the names of the individual step 'Variables' are all included in the test results Report.

				PVT Configura	ation		< >	Add Condition
		Tes	t Condi	tions		- • ×		Delete Condition
New Condition	n Group:	SJ		-				Edit
Description:		Sweep SJ						Apply To Tests
Condition To Add: SJ3				Variable	Value	-		Save As Default
Description: SJ3				SJ1	1ps 2ps	-		Restore Default
Ad	id bi	1		SJ3	3ps	_		🗌 Include I
			<		- F.A.	3 ×		

FIGURE 108 ADD FIRST PVT AUTOMATION PARAMETER

3. Enter one or more parameter value for the steps of the test condition sequence. Take care to include the suffix for the units, and to assign values which are appropriate for that parameter according to the PCIE3 specification. See Figure 109, which shows four steps for parameter 'SJ', named 'SJ1', 'SJ2', 'SJ3' and 'SJ4', and assigned values 1ps, 1.2ps, 1.8ps and 3ps, respectively. When finished editing the Test Conditions, click on "OK". Note that individual steps may be selected, then edited or removed from the list.

				_	PVT Configura	tion	_	< >	Add Condition	
	-		Tes	t Cond	itions		×		Delete Condition	
	New Condition	on Group:	SJ		-				Edit	
	Description:		Sweep SJ	L			_		Apply To Tests	
	andition To Add. SJ	4			Variable	Value			Save As Default	
	Description: SJ4	Description: SJ4	4			SJ1	1ps 1.2ps	_		Restore Default
		dd	1		5.13	1.8ps			Include Panel	
			-	-		-494				
				<			3			
				0	-	Fdt	-			

FIGURE 109 SET EACH PVT PARAMETER VALUE IN SEQUENCE

4. Add a second parameter. See Figure 110., which adds 'SweepISI', with three values, each expressed as a percentage.

	New Condition Group:	Test Conc SweepISI	itions			De
	New Condition Group:	SweepISI				
_	Description					
		SweepISI				A
	Condition To Add:		Variable	Value	A	Sa
	Description:	-	ISIT	107		Re
	Add		ISI3	20%		_
		<		,	v	
		Ren	ove	Edit		

FIGURE 110 ADD SECOND PVT PARAMETER

5. Repeat setting values to each of the allowed parameters. Those parameters which are not setup with explicit values will use the default value.

6. From the menu, apply the sequences of parameters to the selected tests (see Figure 111 and Figure 112), which builds a "Stress Test Plan".



FIGURE 111 APPLY TO TESTS

☑ ISI1						
✓ ISI1			Delete Con			
	TestName	Stress Tes *	-			
✓ ISI2	Sj Calibration False Insertion Loss Calibration False					
✓ ISI3						
	DM Sinusoidal Interference Calibration					
	CM Sinusoidal Interference Calibration	False	-			
	Stress Voltage Calibration	False	Sale As D			
	Insertion Loss Calibration (Short)	False	1.4.1.7			
	CM Sinusoidal Interference Calibration (Short)	False	Restore D			
	DM Sinusoidal Interference Calibration (Short)	False				
	Stressed Voltage Calibration (Short)	False				
	Insertion Loss Calibration (Long)	False				
	DM Sinuscidal Interference Calibration (Long)	False				
	Stressed Voltage Calibration (Logg)	False				
	Stress Jitter Calibration (Long)	False				
	Stress Voltage Test	False				
	Stress Voltage Test	False				
	Stress Voltage Test	False				
	Stress Jitter Test	False				

FIGURE 112 SELECT APPLICABLE TESTS

7. Select the PVT tests to run (see Figure 113).



FIGURE 113. SELECT PVT TESTS TO RUN

8. Run the tests using the "Run Tests with PVT" button (see Figure 114).

			1					
						Run Test	s	
				ſ	Run	Tests wit	h PVT	

FIGURE 114 RUN TESTS WITH PVT

10.4 Search Algorithm

10.4.1 Jitter Margin Testing

After selecting the parameters and their ranges, the user may select from a list of search algorithms to find the bounds of jitter margin.

Symbol	Algorithm
	Bottom-Up
	Top-Down
	Binary

 TABLE 7. PVT AUTOMATION – INTERNAL JITTER MARGIN SEARCH ALGORITHMS

10.5 Test Results

Results from the selected PVT tests, each using the one or more defined PVT parameters, are collected in the Test Report.

The selected tests are all run, one after the other, for each permutation of the parameters. The parameter defined first is varied most slowly; the last-defined parameter is defined most quickly.

For example, considering the parameters and tests defined and selected in Figure 108 to Figure 113 will iterate as shown in Table 8. (Individual parameter step names are not shown.)

 TABLE 8. PVT AUTOMATION – ITERATION SEQUENCE EXAMPLE

Seq.	SJ	ISI	Tests
1	1.0ps	10%	All 4 Parameter Sweeping Tests
2	1.2ps	15%	All 4 Parameter Sweeping Tests
3	1.8ps	20%	All 4 Parameter Sweeping Tests
4	3.0ps	10%	All 4 Parameter Sweeping Tests
5	1.0ps	15%	All 4 Parameter Sweeping Tests
6	1.2ps	20%	All 4 Parameter Sweeping Tests
7	1.8ps	10%	All 4 Parameter Sweeping Tests
8	3.0ps	15%	All 4 Parameter Sweeping Tests
9	1.0ps	20%	All 4 Parameter Sweeping Tests
10	1.2ps	10%	All 4 Parameter Sweeping Tests
11	1.8ps	15%	All 4 Parameter Sweeping Tests
12	3.0ps	20%	All 4 Parameter Sweeping Tests

10.6 Saving and Loading a PVT Session

When using the PVT Automation software, the "Save As" and "Restore" buttons are not used. To save a session, with all of the PVT parameter information, the test results, and any waveforms, use the "Options" command on the menu bar, then the "Save Session" command.

To load a session back into the software, including the saved parameter settings, use the "Options" command on the menu bar, then the "Load Session" command.

The configuration and session results are saved in a file with the extension '.ses', which is a compressed zip-style file, containing a variety of information.

END_OF_DOCUMENT